Using Central Asian Germplasm to Improve Fruit Quality and Enhance Diversity in California Adapted Apricots

C.A. Ledbetter[a]
United States Department of Agriculture, Agricultural Research Service
San Joaquin Valley Agricultural Sciences Center
9611 S. Riverbend Avenue, Parlier, CA 93648-9757
USA

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Abstract

Fifty years of apricot breeding efforts at the Agricultural Research Service in Parlier, California has led to the development of ten new fresh market and processing varieties. During this period, consumer comments indicated that increased sugar and aroma would be desirable improvements in California produced apricots. In the early 1990's, numerous sources of Central Asian apricot germplasm, both clonal and seedling-derived, were imported and utilized in the breeding program to introduce genetic diversity and improve fruit quality. These Central Asian apricots were generally not well adapted to California's environment, but some accessions did display significantly increased Brix levels, long fruit development periods, diverse fruit colors and shapes as well as other novel characteristics. As a group, Central Asian apricot germplasm is far too small-fruited for fresh markets in North America. First generation hybrids between California adapted apricots and Central Asian accessions were generally more productive than their Central Asian parents, but were still too small in fruit size to be directly usable. Second generation hybrids, obtained through intercrossing elite F_1s or through backcrosses to California adapted hybrids, are very diverse in both fruit and tree characteristics. Fruit sizes adequate for fresh marketing are obtainable in the second generation, and large-fruited clones having significantly elevated Brix levels are also observed. The fruit-ripening season has been extended by two week through breeding with Central Asian apricots, and forthcoming seedlings may extend the fruit ripening period even later. Seedlings obtained to date as a result of breeding with Central Asian apricot germplasm demonstrate that significant gains in fruit quality traits can be obtained in two generations.

INTRODUCTION

California has seen a steady decline in apricot production throughout the last half of the 20th century. A number of reasons are responsible for this decline, including increased urbanization of prime orchard land and decreased consumption of dried and otherwise processed apricots. In 1950 over 18,000 ha of bearing apricot orchards were present in California (Hesse, 1952), but orchard area dwindled to just under 7,700 ha by 2000 (National Agricultural Statistics Service, 2007). Accompanying the decline in apricot orchards was a shift in production areas, from the mild coastal valleys to the harsher climate of the San Joaquin Valley (SJV). Fresh market apricots are now grown primarily in the southern end of the valley whereas apricots grown for processing are primarily in the north, between Modesto and Sacramento.

The production shift to the SJV demonstrated the need for new apricot cultivars that were better adapted to the hot dry climate. Cultivars such as 'Blenheim' and 'Tilton' that were well adapted to the mild costal regions did not perform well in the San Joaquin. New cultivars with resistance to 'pit-burn' would be required for consistent production of high quality fresh apricots in the hotter SJV.

[a] cledbetter@fresno.ars.usda.gov

The Agricultural Research Service (ARS) began breeding apricots adapted to the SJV in the mid-1950s, and introduced 'Castleton' in 1963 (Weinberger, 1963) as the first fresh market apricot cultivar adapted to the SJV's climate. Much early hybridization included 'Perfection' as a parent with other commonly grown cultivars in order to attain increased fruit size and flesh firmness in the resultant progeny. But a by-product of using 'Perfection' came in the form of increased fruit acidity. 'Castlebrite' apricot, released by ARS in 1977, is a classic example of breeding focused on the needs of the fruit producer, and without the consideration of consumers' desire for high quality fruit. Growers appreciated the consistent and heavy crops produced in 'Castlebrite' orchards, but fruit retailers found difficulty in repeat sales of this highly colored but acidic cultivar. By the late 1980s, a decade after the appearance of 'Castlebrite' on store shelves, consumers were loudly demanding higher quality apricots.

MATERIALS AND METHODS

Apricot seedlots, or dormant budwood of clonal and seedling Central Asian apricot accessions were received at the ARS laboratory in Parlier, CA only after clearing plant protective quarantine at the USDA-Animal & Plant Health Inspection Service facility in Glenn Dale, Maryland. Central Asian accessions were established in the research orchard where vegetative and fruiting characteristics could be evaluated alongside apricot accessions adapted to the California environment. Fruit quality characteristics were evaluated objectively using methods previously described (Ledbetter et al., 1996). Novel or new characteristics of interest (late bloom period, strong fruit attachment, long fruit development period and unique color or fruit shape) were identified in accessions that would be used in hybridizations. Full bloom dates and fruit developmental periods were evaluated subjectively through direct observation in the research orchard.

Conventional breeding techniques were used to create all the hybrids used in the program. Initial evaluations of hybrids occurred on own-rooted seedlings that were planted within the row at 50 cm spacing. Hybrids selected for further breeding or commercial trialing were dormant grafted on 'Nemaguard' peach rootstock and planted at 4 m intervals.

RESULTS AND DISCUSSION

Political changes on the Asian continent in the 1980s allowed USDA researchers new opportunities in collaboration and germplasm exchange. Several important plant collection expeditions to Central Asia occurred in the late 1980s and early 1990s, and numerous *Prunus* accessions were imported to the US and placed in protective quarantine. Among these accessions were numerous apricots from the Hunza region of Pakistan, as well as other Central Asian apricot accessions from regions within the former Soviet Union.

Central Asian Apricots in the San Joaquin Valley

The largest group of Central Asian apricots arrived in California as seedlots during 1989. The seedlots were collected along with dormant scions from unique apricot cultivars found throughout the Hunza region of Pakistan. Although none of the collected 102 dormant scions survived protective quarantine (Thompson, 1998), open-pollinated seedlots from the clones were distributed to interested US researchers for evaluation and breeding. Fifty-three seedlots were received at the ARS station in Parlier, California and planted out for tree and fruit evaluations, and the possibility of use in apricot breeding (Ledbetter and Peterson, 2004). Much genetic diversity existed among fruiting trees from the Hunza seedlots, and as a group they exhibited several classic characteristics as have been described for apricot germplasm of Central Asian origin (Bailey and Hough, 1975). Other Central Asian apricot cultivars (or seedlings derived from them) passed through protective quarantine and were established in the ARS research orchard between 1993 and 1998 (Table 1).

Without exception, Central Asian apricots trialed in the SJV produced only limited quantities of fruit, compared to California-bred and adapted apricots. However, specific characteristics expressed by Central Asian germplasm in California made them extremely valuable as parents in the ARS breeding program. Elevated Brix levels, as compared to California adapted apricots, was the most important trait identified in numerous Central Asian accessions. Late bloom period was another character that was common to many Central Asian apricots, and extended fruit developmental period was also noted. White flesh and glabrous skin were observed on several Central Asian accessions, and these apricots were also utilized in the breeding program. Particularly common among the Pakistani apricots was a strong fruit attachment character. In trees having this character, fruit remained on the tree at full ripeness, and would dry or 'raisin' without falling from the tree.

Central Asian x California Adapted Hybrids

Hybridizations involving Central Asian and California adapted apricots began speculatively in 1993 and continued through 2003, with fruit production from F_1 hybrids beginning in 1997. Consistent among many of the F_1 progenies were much improved fruit production as compared to the original Central Asian parents. High Brix and fruit color segregated in some F_1 progenies, as did date of full bloom. Glabrous skin was absent in all F_1s where a glabrous parent was hybridized with California adapted apricots. The strong fruit attachment character was observed in irregular segregations throughout some of the progenies.

Vegetatively, many Central Asian x California hybrid trees showed classic signs of heterosis as evidenced by trunk diameters and relative pruning weights of similar aged California adapted trees. Spur density was typically higher in F_1s, and one-year old branch diameters were smaller, as compared with the California adapted parent. Fruit from F_1 hybrids was almost always far too small for fresh marketing purposes, even after trees had been properly thinned. Fruit evaluations from over 1,100 F_1s demonstrated the need for interhybridization amongst the F_1s or backcrossing elite F_1s with California adapted accessions in order to incorporate the favorable traits from the Central Asian germplasm into the larger-fruited California adapted apricots.

Several seasons of fruit evaluations have now been accomplished on the first of many progenies that resulted from backcrosses to California adapted types, and interhybridization of F_1 hybrids. We have succeeded in combining the favorable characteristics of California adapted apricots with specific traits of interest found in Central Asian germplasm (Table 2). As a result of their use, the ARS apricot breeding program now has numerous advanced selections that ripen from mid-May through the end of June with Brix levels in the mid-20s and average fruit weights greater than 70 g. Glabrous-skinned apricots are now segregating in progenies where glabrous Uzbek apricots were initially used as a grandparent. Furthermore, the fruit ripening season in Central California has been extended by at least two weeks through the utilization of Central Asian apricots. The modification of fruit sugar profiles has been documented (Ledbetter et al., 2006) through the use of Pakistani germplasm, and future analyses will examine the enhanced genetic diversity resulting from the introgression of other Central Asian germplasm into California adapted apricots.

The initial results of introgressing Central Asian germplasm into California adapted apricots are encouraging, and demonstrate the genetic gains possible in just two generations, even when using germplasm generally unadapted to the California environment. Several Central Asian x California adapted hybrids are currently being trialed in commercial apricot orchards, with performance and marketplace acceptance being determinants in their fate as potential new cultivars.

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Tables

Table 1. Central Asian apricot germplasm imported and utilized in breeding to enhance fruit quality of California adapted apricots.

Accession	Country of origin	Passed quarantine	Received as
Shallah	Armenia	1998	clonal
53 Hunza seedlots	Pakistan	1989	seedlots
Yhulag	Tajikistan	1993	seedling
Ak Khurmay	Turkmenistan	1998	clonal
Gulyungi Katta	Turkmenistan	1998	clonal
Luchak # 1	Uzbekistan	1993	seedling
Luchak White #3	Uzbekistan	1994	seedling
Wimpell	Uzbekistan	1996	seedling

Table 2. Elite apricot accessions and their important characters obtained through introgression of Central Asian germplasm into California adapted apricots.

Accession	Year of hybridization	Central Asian parent	Selection based upon
Y103-A	1994	Burum Gakas	Very late maturity, high fruit sorbitol, prolonged ripening period
Y104-A	1997	Luchak # 1	Glabrous skin, bright orange flesh
Y116-A	1997	Yhulag	Late bloom, drying quality
Y117-A	1997	Kaisi	Non-melting flesh type, unique fruit shape, high Brix
Y117-B	1997	Shobaig	Very late maturity, self-compatible
Y118-A	1994	Bulbil-E-Shikanda	Very high Brix, firm flesh, high skin blush